AD A072064

AMRL-TR-79-65

THE ROLE OF THE UPPER FIELD OF VIEW IN SELECTED HMS/D VISUAL TASKS

B. J. COHEN
R. A. LEVIT

Honeywell Systems and Research Center
2700 Ridgway Parkway
Minneapolis, Minnesota 55413

JULY 1979

Approved for public release; distribution unlimited

AEROSPACE MEDICAL RESEARCH LABORATORY
AEROSPACE MEDICAL DIVISION
AIR FORCE SYSTEMS COMMAND
WRIGHT-PATTERSON AIR FORCE BASE, OHIO 45433

79 07 31 049

DDC ACCESSION NUMBER

II

LEVEL

DATA SHEET

PHOTOGRAPH

THIS SHEET

I

INVENTORY

AMRL-TR-79-65

DOCUMENT IDENTIFICATION

DISTRIBUTION STATEMENT A

Approved for public release;
Distribution Unlimited

DISTRIBUTION STATEMENT

Accession For	
NTIS GRA&I	X
DDC TAB	
Unannounced	
Justification	
By	
Distribution/	
Availability Codes	
Dist	Avail and/or special
A	

DISTRIBUTION STAMP

DDC
RECEIVED
AUG 1 1979
D

DATE ACCESSIONED

79 07 31 049

DATE RECEIVED IN DDC

PHOTOGRAPH THIS COPY

NOTICES

When US Government drawings, specifications, or other data are used for any purpose other than a definitely related Government procurement operation, the Government thereby incurs no responsibility nor any obligation whatsoever, and the fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data, is not to be regarded by implication or otherwise, as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use, or sell any patented invention that may in any way be related thereto.

Please do not request copies of this report from Aerospace Medical Research Laboratory. Additional copies may be purchased from:

National Technical Information Service
5285 Port Royal Road
Springfield, Virginia 22161

Federal Government agencies and their contractors registered with Defense Documentation Center should direct requests for copies of this report to:

Defense Documentation Center
Cameron Station
Alexandria, Virginia 22314

TECHNICAL REVIEW AND APPROVAL

AMRL-TR-79-65

This report has been reviewed by the Information Office (OI) and is releasable to the National Technical Information Service (NTIS). At NTIS, it will be available to the general public, including foreign nations.

This technical report has been reviewed and is approved for publication.

FOR THE COMMANDER

CHARLES BATES, JR.
Chief
Human Engineering Division
Aerospace Medical Research Laboratory

79 07 31 049

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: AMRL-TR-79-65
2. GOVT ACCESSION NO.:
3. RECIPIENT'S CATALOG NUMBER:
4. TITLE (and Subtitle): THE ROLE OF THE UPPER FIELD OF VIEW IN SELECTED HMS/D VISUAL TASKS
5. TYPE OF REPORT & PERIOD COVERED: Technical Report
6. PERFORMING ORG. REPORT NUMBER: F4001-HSR1
7. AUTHOR(s): R. J. Cohen, R. A. Levit
8. CONTRACT OR GRANT NUMBER(s): F33615-72-C-0420/PZ0002
9. PERFORMING ORGANIZATION NAME AND ADDRESS: Honeywell Systems and Research Center, 2700 Ridgway Parkway, Minneapolis, Minnesota 55413
10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: 5973
11. CONTROLLING OFFICE NAME AND ADDRESS: Aerospace Medical Research Laboratory, Aerospace Medical Division, Air Force Systems Command, Wright-Patterson Air Force Base, Ohio 45433
12. REPORT DATE: 12 July 1979
13. NUMBER OF PAGES: 37
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office):
15. SECURITY CLASS. (of this report): UNCLASSIFIED

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE:

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

A study was conducted to determine whether opaque obstructions located in an observers's upper field of view would affect the visual detection of briefly illuminated targets located above his horizontal line of sight. Five versions of an acrylic visor considered for use with a helmet-mounted sight and display (HMS/D) contained one or more opaque areas located above their horizontal axes. Target detection performance for 12 subjects using the experimental visors was compared with the subjects' performance using an unobstructed control visor. Target appearance was signalled by a central cue light for six subjects

(See reverse)

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

20. (directed search), while the other six subjects were forced to rely only on peripheral detection of the briefly illuminated targets (undirected search). It was found that target detection performance was unaffected by either visor obstructions or by method of search, or any combination of the two. It was concluded that any of the visors would be usable from a visual performance standpoint.

CONTENTS

		Page
SECTION I	INTRODUCTION	1-1
	Background	1-1
	Statement of the Problem	1-1
	Hypotheses	1-2
SECTION II	METHOD	2-1
	General	2-1
	Subjects	2-1
	Apparatus	2-1
	Procedure	2-8
	Experimental Design and Data Analysis	2-10
SECTION III	RESULTS	3-1
	Number of Correct Target Identifications	3-1
	Response Latency	3-1
SECTION IV	CONCLUSIONS	4-1
	Learning Effects	4-2
	Implication for Future Research	4-2
	References	4-5
APPENDIX A	INSTRUCTION TO SUBJECTS	
APPENDIX B	TARGET PRESENTATION SCENARIO	
APPENDIX C	RAW DATA	

ILLUSTRATIONS

Figure		Page
1	Hypothesized Relationship Between Visor Obscuration and Type of Visual Task	1-3
2	Block Diagram of Subject-Apparatus Interface	2-2
3	Helmet, Padding, and Visors Used in the Present Study	2-3
4	Targets Used in the Present Study (Target 11 was not within the camera's field of view)	2-5
5	Alignment of Subject's Eye Position by Adjustment of Chair Until Plumb-Bob Over Right Pupil is Centered in Steel Ring	2-6
6	Subject's Response Console. (Top row buttons used to acquire primary targets; bottom row buttons/switches associated with secondary task.)	2-7
7	Subject Performing Primary Task of Acquiring Targets 5, 1, and 13	2-9
8	Mean Correct Response (Target Identification) as a Function of Visor Type for Directed and Undirected Search Groups	3-2
9	Mean Response Time as a Function of Visor Type for Directed and Undirected Search Groups	3-4
10	Response Latency as a Function of Trial	4-3

TABLES

1	Experimental Counter-Balanced Design	2-11
2	Summary Table for a 6x2 Analysis of Variance Testing for Significant Differences in Correct Responses (Target Identification) Across Experimental Group and Visor Type	3-3
3	Summary Table for a 6x2 Analysis of Variance Testing for Significant Differences in Response Latency Across Experimental Group and Visor Type	3-5

SECTION I
INTRODUCTION

BACKGROUND

Some of the most advanced versions of the Honeywell Integrated Helmet Sight and Display (IHMS/D) system project a collimated CRT image directly onto a parabolic visor rather than a combining glass. To minimize optical distortion, the pencil of rays is reflected back from the visor twice before entering the eye by means of a central mirror located in the observer's upper field of view. In addition, small opaque areas are located in the upper field of view to minimize contrast loss due to incoming stray rays of light which may accidentally enter the optical path. Ideally, the observer's visual field should be totally unobstructed except for that portion where data and imagery are displayed. Since this may not be possible, the present study was conducted to determine if such obstructions would actually interfere with the performance of selected visual tasks.

STATEMENT OF THE PROBLEM

Of the many potential uses of the IHMS/D considered (Hughes et al., 1969; Cohen et al., 1972; Jacobs et al., 1971), the air-to-air combat mission was identified as one of the most significant. In this mission, the pilot must not only maneuver his aircraft to the most advantageous position to avoid enemy missiles and automatic cannon fire, but must also close with an destroy the enemy aircraft. In the direct-fire situation, he must maneuver the aircraft so that he can place a symbol projected on his visor over the target. The pilot's line of sight is therefore directed at a single target, and any additional targets entering his field of view must be detected peripherally before he can direct his attention to them and determine their threat potential. If portions of the pilot's upper field of view are obstructed, his peripheral vision might be degraded in a way which would prevent the detection of other targets until it was too late. Similarly, if both the pilot's line of sight and his attention were directed downward and into the cockpit, the detection of enemy aircraft might be more difficult if his peripheral vision were obstructed. On the other hand, if the pilot's attention were drawn to an approaching aircraft by a warning light in his foveal field of view, he could quickly shift his attention (and his foveal field of view) to the appropriate position for recognizing the aircraft as friend or foe.

HYPOTHESES

The above discussion described the relative roles of central and peripheral vision in the detection of targets located above the pilot's normal line of sight. Persumably, "directed search" would cause the pilot to look in the general target area and thus detect targets with his central vision. Alternatively, if he were not directed to look in the target area ("undirected search"), he would have to rely on his peripheral vision to detect targets. With this distinction between directed and undirected search in mind, it was hypothesized in the present study that visors with obstructions in the upper field of view would interfere with target detection tasks in which the observer was not looking upward toward the target area, but must instead rely on his peripheral vision to detect targets. Furthermore, the amount of task interference would be proportional to the amount of upper field-of-view obscuration. On the other hand, if the observer were forewarned that a target was about to appear, he would direct his attention (and his foveal vision) toward the target area. In this case, it was hypothesized that the obstructions would have no effect on target detection since they would be out of his foveal field of view. In statistical terms this means that if the field-of-view obstructions differentially affect visual performance in the predicted manner, there will be significant treatment effects for visors and tasks, and for the visor by task interaction. The predicted relationships are shown in Figure 1.

that if the field-of-view obstructions differentially affect visual performance in the predicted manner, there will be significant treatment effects for visors and tasks, and for the visor by task interaction. The predicted relationships are shown in Figure 1.

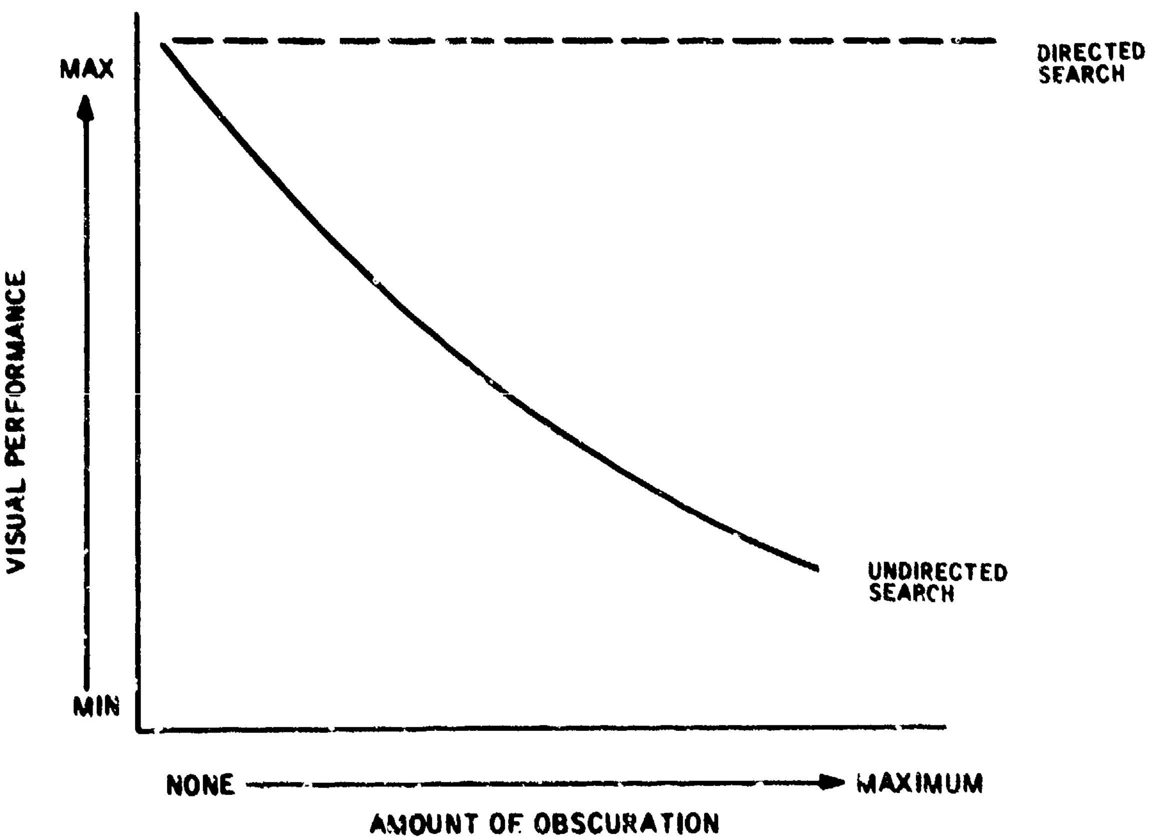

Figure 1. Hypothesized Relationship Between Visor Obscuration and Type of Visual Task

SECTION II
METHOD

GENERAL

The experiment was designed to simulate selected aspects of the pilot's mission and cockpit environment. The experimental situation required the subject to detect/recognize briefly-illuminated targets (primary task) while engaged in an in-cockpit task (secondary task). The purpose of the secondary task was to direct and maintain the subject's central vision downward, in a fashion similar to a pilot performing tasks that require that his attention be directed primarily into the cockpit area.

SUBJECTS

Nine male and three female university students participated in the experiment. Subject ages ranged from 20 to 30 years, with a mean age of 23. All subjects had 20/20 corrected vision with no significant ocular pathology, and were paid for their participation.

APPARATUS

Figure 2 illustrates the sequence of operation of the apparatus for the primary and secondary tasks. The apparatus consisted of the components described below.

A pilot's helmet was modified to accept each of six curved acrylic visors. Figure 3 shows this apparatus. Five of the visors were occluded by masking tape in configurations that represented possible areas of occlusion in the prototype helmet display. One clear visor (Visor "A") was used as a control.

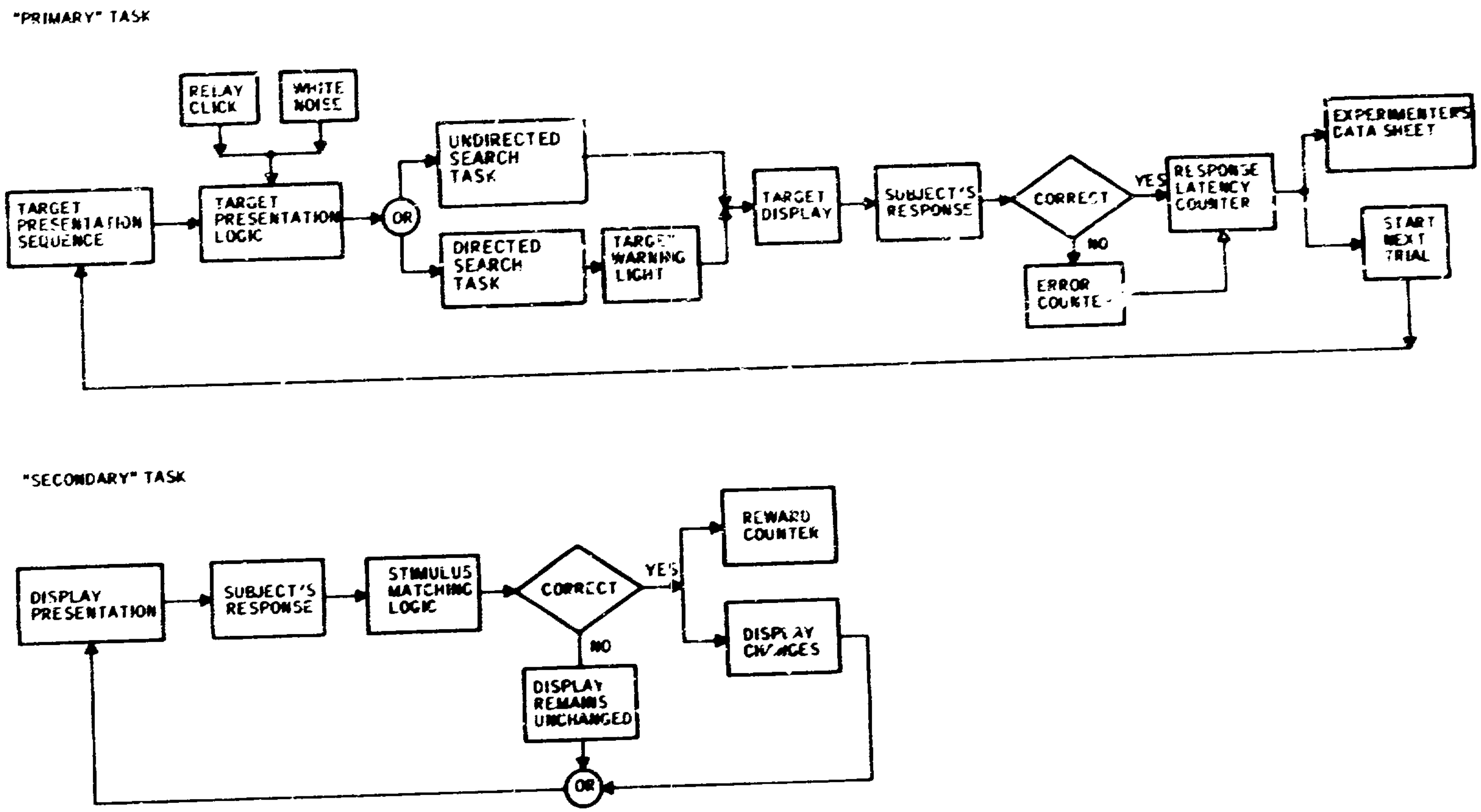

Figure 2. Block Diagram of Subject-Apparatus Interface

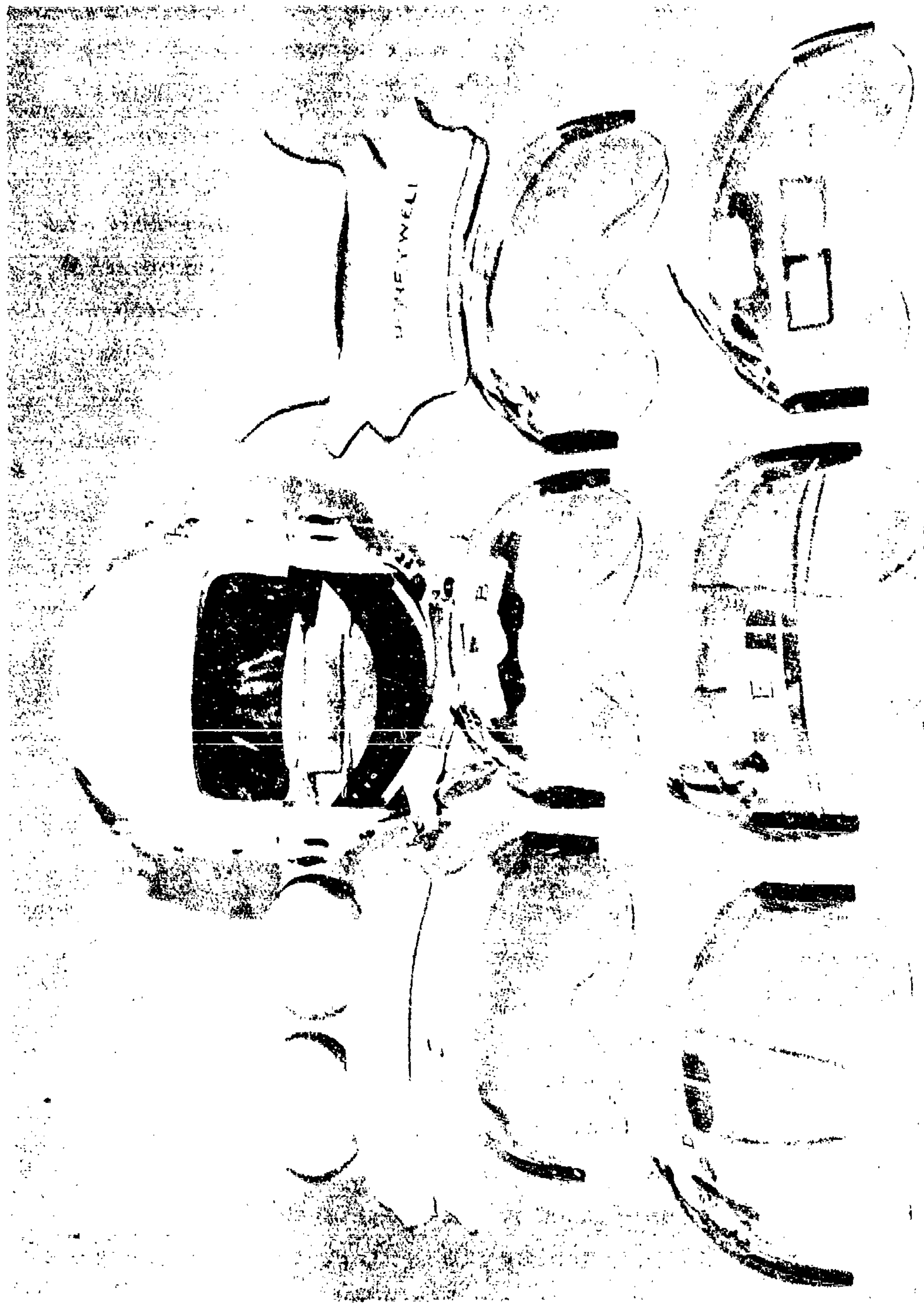

Figure 3. Helmet, Padding, and Visors Used in the Present Study

The primary targets consisted of 16 ceiling-mounted one-inch black numerals, numbered from 1 to 16 but arranged nonsequentially and superimposed on frosted acetate. Targets were back-illuminated with 60-watt lamps. The target stimuli are shown in Figure 4. Targets were placed so that four (numbers 5, 13, 11, and 15) were visible to a subject in a standardized position (aligned with a plumb-bob over his right eye, as shown in Figure 5), while the other 12 were obscured. The structure of the target assembly and the requirement for precise alignment of the targets precluded placement of the targets equidistant from the subject's eye position. It was assumed, however, that the counterbalanced order of presentation of all targets to all subjects would eliminate any bias attributable to differences in target distance. Six subjects in a pilot study showed no performance differences attributable to target distance.

The subject performed the experimental task using a console of local design which was positioned to direct his line of sight downward from the horizontal (up to a 40-degree depression angle) so that none of the targets was within his foveal field of view. Briefly, the subject was required to divide his attention between an in-cockpit (secondary) task of responding to a series of three sets of three lights, while at the same time responding to a sequence of primary targets. The console apparatus is shown in Figure 6. The subject performed the secondary task by setting three switches to correspond to the sequence of lights appearing on the console. Only one light in each of the three sets could appear at any one time; the total sequence was randomized. The secondary task was made more complex by the arbitrary ordering of response switch settings. That is, the order of the switch settings did not correspond with the secondary light positions. Again, this was done to direct the subject's vision downward and maximize his attention to the "in-cockpit" task.

The subject responded to the primary task by pressing three of a series of 16 sequentially mounted buttons corresponding to the targets which appeared on a particular trial. Primary targets appeared in randomized sequences of

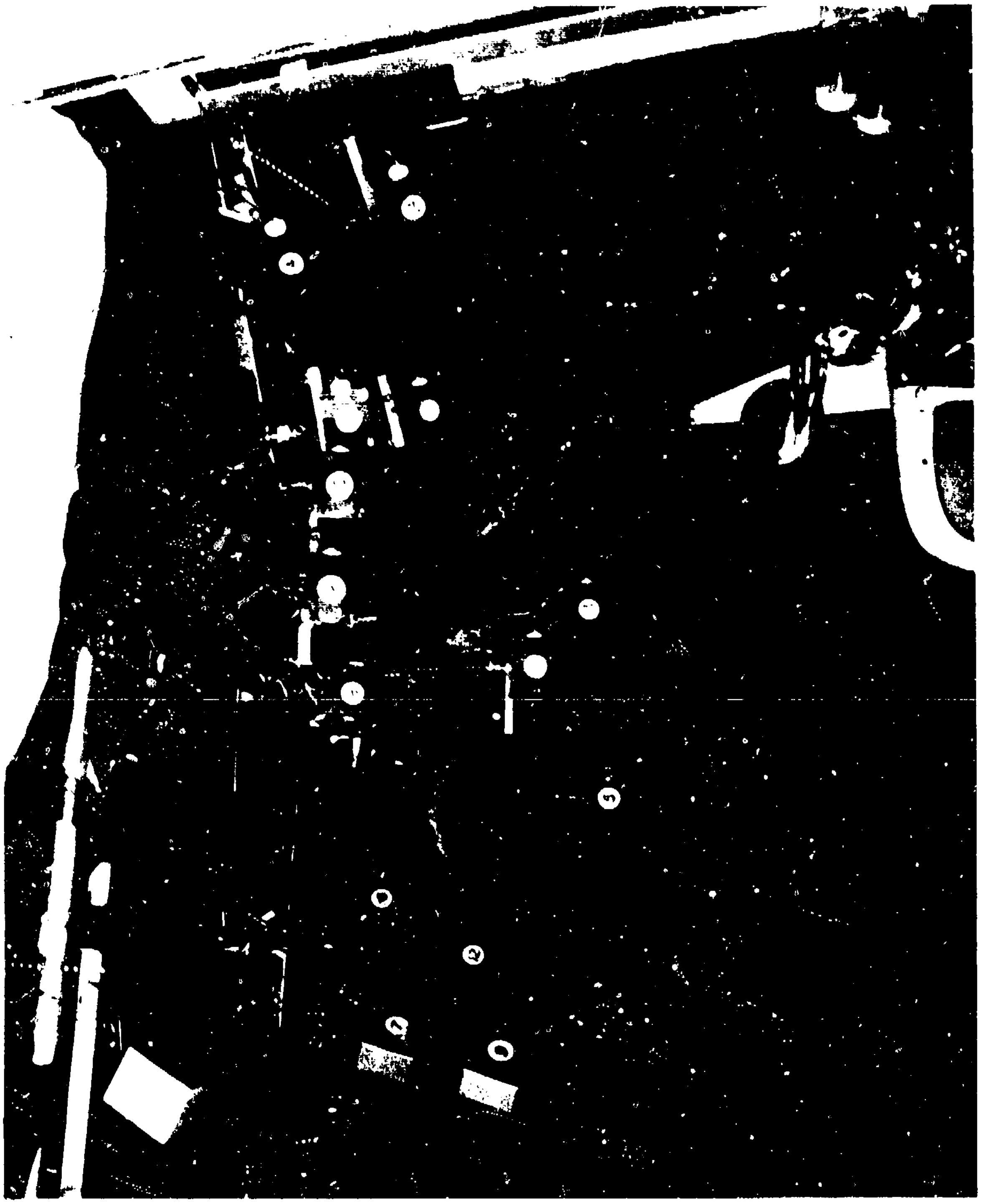

Figure 4. Targets Used in the Present Study (Target 11 was not within the camera's field of view)

Figure 5. Alignment of Subject's Eye Position by Adjustment of Chair Until Plumb-Bob Over Right Pupil is Centered in Steel Ring

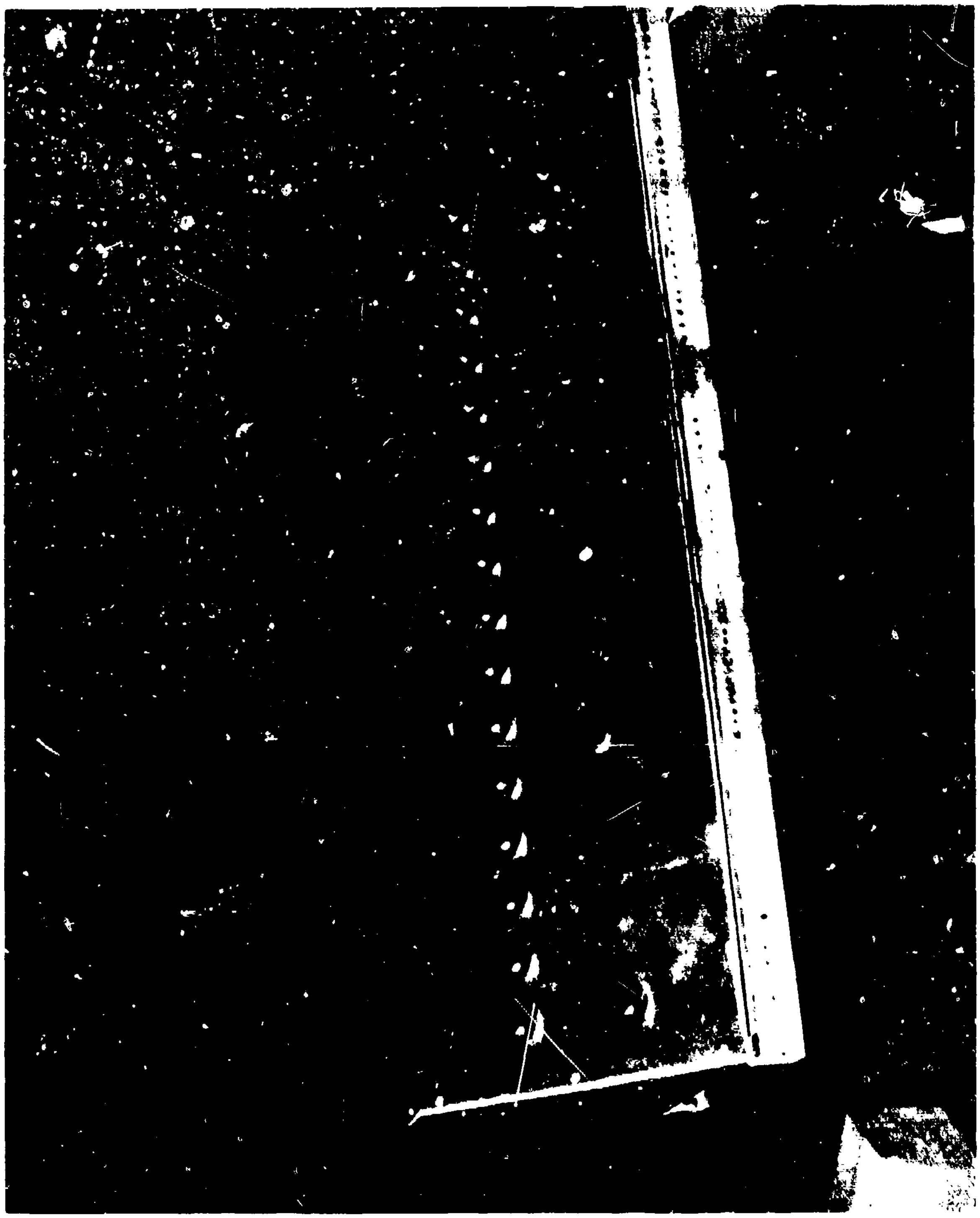

Figure 6. Subject's Response Console. (Top row buttons used to acquire primary targets; bottom row buttons/switches associated with secondary task.)

threes for two seconds, 16 times for each of the six visors. The targets appeared at four randonized interstimulus intervals of 22 25, 32, and 40 seconds. Primary targets were presented in either a directed or undirected search mode. In the undirected search mode, the subject was required to identify the targets without any forewarning of their appearance. In the directed search mode, a small green light mounted in the center of the console signaled target onset. The console also contained a series of counters to tally subject performance (number of secondary tasks completed and number of primary targets "missed"). Figure 7 shows a subject performing the primary task.

A rack-mounted logic system of local design controlled the sequence of trial events in the primary and secondary tasks. Since the primary target onset was triggered by a bank of electromechanical relays, it was necessary to mask the sound of the relays with a 60-decibel white noise so that the subject would not learn to use these sounds as a signal to look up in anticipation of target illumination. A further control for relay noise was provided by a timer which cycled "dummy" relay clicks on a 0.4 probability schedule every 30 seconds.

The dependent variables (number of correct identifications and response latency) were recorded on console-mounted electromechanical event counters and Hunter electronic "Klock-Kounters" (Model 120A, series D), respectively.

PROCEDURE

The subject was seated in a dental chair and fitted wit the helmet using the foam inserts shown in Figure 3 to obtain a sn g fit. The subject was then aligned so that his right eye was in the standardized position described in the apparatus section and shown in Figure 5.

Figure 7. Subject Performing Primary Task of Acquiring Targets 5, 1, and 13

The experimenter then read the instructions (Appendix A) to the subject. When the subject both fully understood the instructions and the helmet was properly fitted and positioned, eight training trials were given. This value was selected because a previous pilot study showed a distinct leveling off of performance by the eighth trial. When this was concluded, the formal data collection began.

The six subjects in the undirected search group had to identify, without warning, the appearance of primary targets while engaged in the "secondary" in-cockpit task. The six subjects in the directed search group were given a one-second warning (a green light) concurrent with primary target onset.

The subject responded correctly, in both tasks, if he identified the primary target sequence within a five-second available response interval. This interval was selected because data from a three-subject pilot study showed that target acquisitions within various time intervals were distributed with the majority of acquisitions occurring between two and five seconds.

The subject was incorrect if (1) he misidentified the sequence or (2) if he took longer than five seconds to respond. Subjects were paid 5 cents for a correct identification and penalized 50 cents for either type of incorrect response. It was assumed that this combination of positive and negative reinforcement would serve to maintain a high level of involvement among the subjects.

EXPERIMENTAL DESIGN AND DATA ANALYSIS

Primary targets were presented in blocks of 16, three targets being presented on each trial. Primary target presentations were randomized within blocks. Appendix B details the target presentation scenario. Presentation of target stimuli to subjects was counterbalanced across subjects. Details of the counterbalanced design are presented in Table 1.

Table 1. Experimental Counter-Balanced Design

Subject	Directed Search						Subject	Undirected Search					
1 Visor	A	B	C	D	E	F	7 Visor	A	B	C	D	E	F
Target Block	I	II	III	IV	V	VI	Target Block	I	II	III	IV	V	VI
2 Visor	B	C	D	E	F	A	8 Visor	B	C	D	E	F	A
Target Block	III	IV	V	VI	I	II	Target Block	III	IV	V	VI	I	II
3 Visor	C	D	E	F	A	B	9 Visor	C	D	E	F	A	B
Target Block	V	VI	I	II	III	IV	Target Block	V	VI	I	II	III	IV
4 Visor	D	E	F	A	B	C	10 Visor	D	E	F	A	B	C
Target Block	I	II	III	IV	V	VI	Target Block	I	II	III	IV	V	VI
5 Visor	E	F	A	B	C	D	11 Visor	E	F	A	B	C	D
Target Block	III	IV	V	VI	I	II	Target Block	III	IV	V	VI	I	VI
6 Visor	F	A	B	C	D	E	12 Visor	F	A	B	C	D	E
Target Block	V	VI	I	II	III	IV	Target Block	V	VI	I	II	III	IV

Two dependent variables were measured as a function of visor type in this study. Those dependent variables were:

- Number of correct target identifications
- Response latency for right and wrong target identifications

Parallel 6 x 2 fixed-effects analyses of variance were performed on data for each of the dependent variables to test for:

- Significant differences in subject performance across visor type
- Significant differences in subject performance across task
- Significant interactions between visor type and task

SECTION III
RESULTS

NUMBER OF CORRECT TARGET IDENTIFICATIONS

Figure 8 presents the mean number of correct responses (target identifications) as a function of visor type for the directed and undirected visual detection groups. The raw data may be found in Table C1 of Appendix C.

The figure and the supportive analysis of variance (Table 2) indicate that there were no significant differences between the directed and undirected search groups on the "number correct" measure or between visor types for all subjects pooled. In addition, no significant interactions were found between either experimental group and visor type.

RESPONSE LATENCY

Figure 9 presents the mean response time as a function of visor type for the directed and undirected groups. The raw data may be found in Table C2 of Appendix C.

The figure and the supportive analysis of variance (Table 3) indicate that there were no significant differences between the groups on the "response latency" measure or between visor types for all subjects pooled. In addition, no significant interactions were found between either experimental group and visor type.

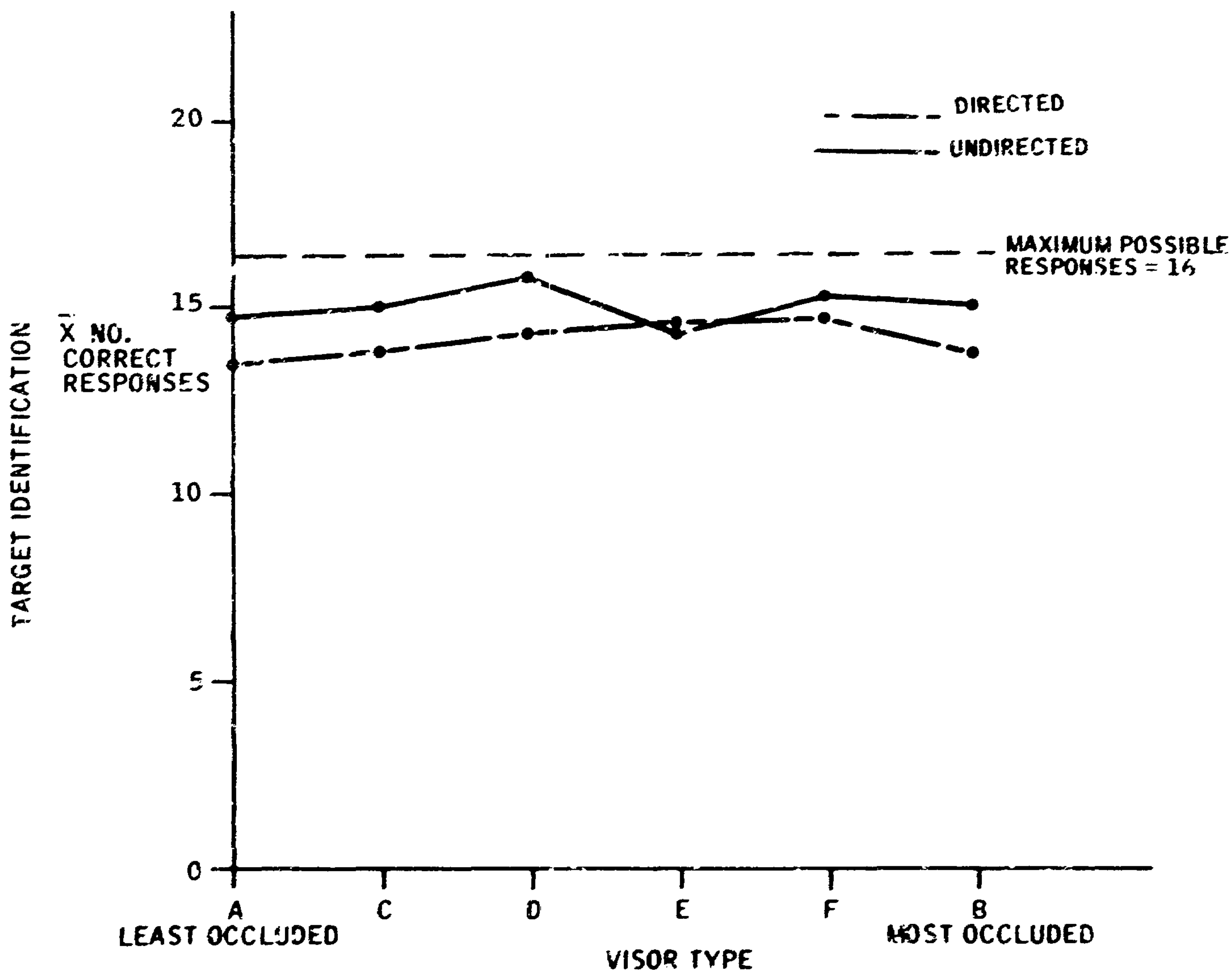

Figure 8. Mean Correct Response (Target Identification) as a Function of Visor Type for Directed and Undirected Search Groups

Table 2. Summary Table for a 6x2 Analysis of Variance Testing for Significant Differences in Correct Responses (Target Identification) Across Experimental Group and Visor Type

Source	s. s.	d. f.	m. s.	F
Tasks (T)	17.11	1	17.11	--
$Error_T$	227.00	10	22.70	
Visors (V)	7.11	5	1.42	--
TXV	6.56	5	1.31	--
$Error_V$	91.33	50	1.83	
TOTAL	349.11	71		

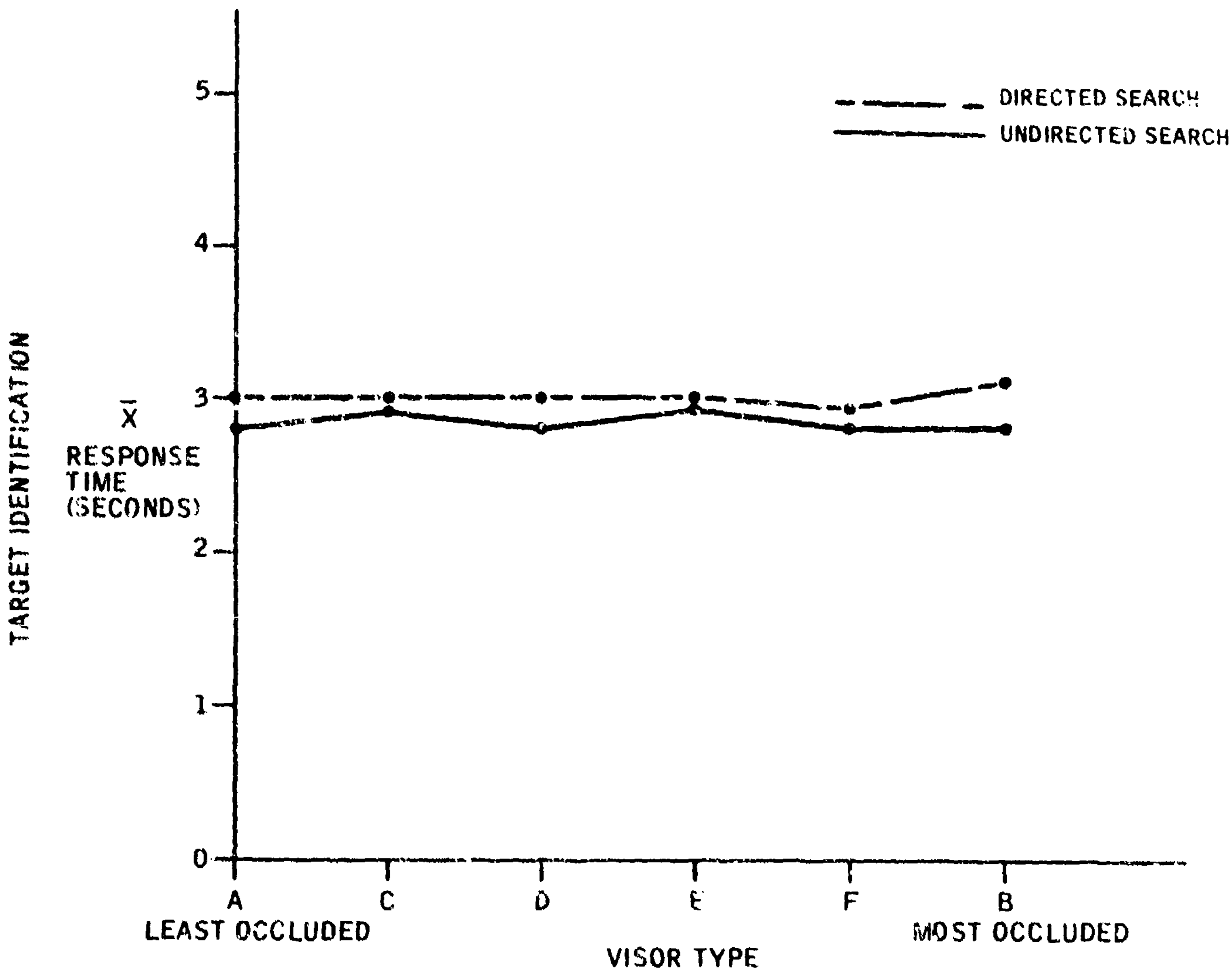

Figure 9. Mean Response Time as a Function of Visor Type for Directed and Undirected Search Groups

Table 3. Summary Table for a 6x2 Analysis of Variance Testing for Significant Differences in Response Latency Across Experimental Group and Visor Type

Source	s. s.	d. f.	m. s.	F
Tasks (T)	0. 52	1	0. 52	--
$Error_T$	6. 11	10	0. [illegible]1	
Visors (V)	0. 06	5	0. 01	--
TXV	0. 07	5	0. 01	--
$Error_V$	1. 11	50	0. 02	
TOTAL		71		

SECTION IV
CONCLUSIONS

Basically, the experimental evidence indicates that the visor configurations tested did not degrade visual target acquisition performance. It must be emphasized that these results do not generalize to visor configurations other than those tested. Essentially, these results show:

1) No significant differences on performance across visor type

2) No significant differences in performance across experimental task (directed versus undirected search)

3) No significant interactions between visor type and experimental task

Thus, we can conclude that the visor configurations tested do not significantly interfere with target acquisition tasks, and presumably would not interfere with the pilot's performance of an air-to-air combat mission.

Harder to explain is the finding that subjects in the directed search group, who were forewarned of a target's appearance, did no better than those in the undirected search group. All other conditions being the same, the undirected search task appears to be inherently more difficult, and this should have been reflected in a significant task difference. Two explanations seem plausible:

1) The subjects were randomly assigned to the two task groups, but the directed search group was run first, thus confounding tasks with subjects. Subtle changes in the experimental environment may have occurred that improved the performance of the second

group so that they did as well as the first group. This might have been prevented if the order of presentation of task conditions had been randomized rather than confounded.

2) All subjects were allowed freedom of head movement. Those in the undirected search group could therefore minimize the likelihood of missing a target by continually glancing up while performing the secondary task. This could have been prevented if a head restraint, such as a "bite-bar" had been used, but that would have added a high degree of unrealism to the situation.

LEARNING EFFECTS

As a side issue, learning effects were also evaluated to determine if target acquisition performance improved with practice and if there were any differential performance changes over time for the two target acquisition groups. A tabulation of mean response latencies as a function of trial was performed for the two groups. There was no apparent change in performance over 96 trials, as shown in Figure 10. Thus, we can conclude that there was no performance improvement or decrement over the course of the experiment for either target search group as a function of either learning or fatigue.

IMPLICATION FOR FUTURE RESEARCH

The present study has addressed only a limited aspect of the air-to-air combat mission; namely, a close-in, highly visible target in front of and slightly above the pilot. In this case it was found that the five occluded visors did not

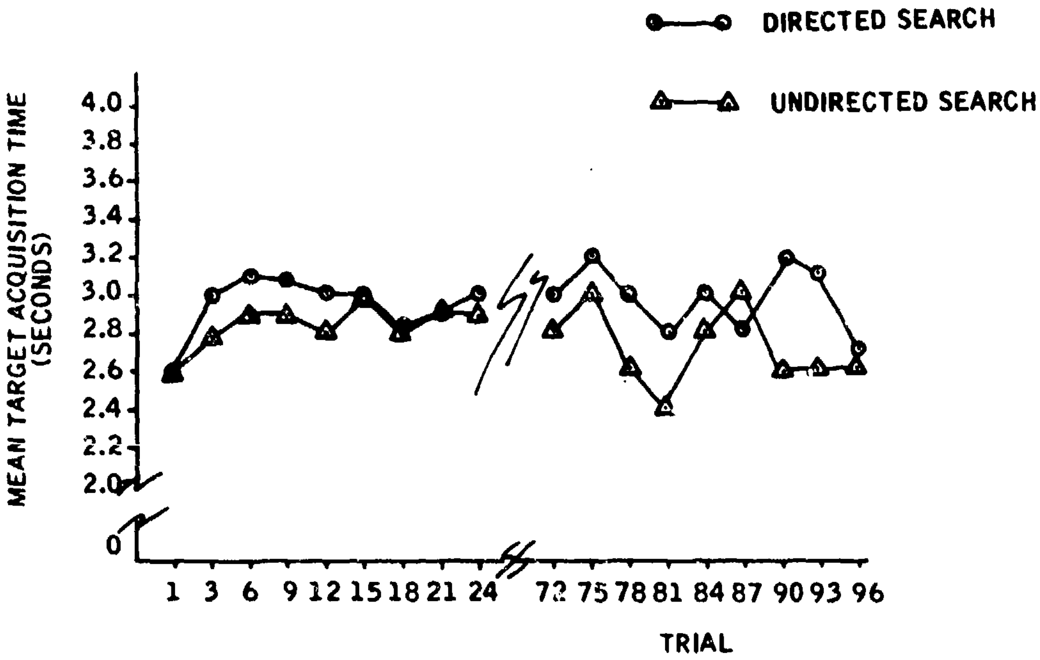

Figure 10. Response Latency as a Function of Trial

interfere with the acquisition of these targets. There are still some unanswered questions, however, that relate to the basic problem of obstructions in the pilot's field of view. These are questions of target location, dynamics, and configuration, and also of degree of occlusion. Specifically, the issues to be considered are:

1) Effect of targets located below line of sight and to the side and rear of the pilot.

2) The effect of target speed and direction of movement -- targets in the present study were static.

3) The effect of targets varying in size, shape, color, and brightness. The targets in the present study were large, brightly lit, and did not vary in color and shape as targets do in the real world.

4) How much of the pilot's field of view must be obstructed before target acquisition performance is significantly affected? This last point may be very critical because the Air Force has been considering a system using a heavily filtered off-axis display* in which a low-transmission combiner would be located below the pilot's line of sight so that the display image would tend to block out portions of his lower field of view.

*Personal communication - J. L. Porterfield, USAF (AMRL).

REFERENCES

1. Cohen, B.J., Henke, A.H., and Williams, L.G., A research program for investigating human performance with the helmet-mounted sight and display (HMS/D) system. Honeywell Inc., Minneapolis, Minnesota. Systems and Research Division document Z9500-3011, July 1972.

2. Hughes, R.J., Henke, A.H., and Schultz, R.L., Helmet-mounted sight/display applications. Volume IV: Baseline HMS/D system. Air Force Technical Report AFFDL-TR-69-118. Vol. IV, December 1969.

3. Jacobs, R.S., Triggs, T.J., and Aldrich, J.W., Helmet-mounted display/sight system study. Air Force Flight Dynamics Laboratory, Wright-Patterson Air Force Base, Ohio. Technical Report AFFDL-TR-70-83, Vol. 1, March 1971.

4. Williams, L.G., Fairchild, D.D., Graf, C.P., Jola, J.F., and Trumm, G.A., Visual search effectiveness for night vision devices. Contract No. DAAK02-67-C-0472, Army Night Vision Laboratory. Fort Belvoir, Virginia. May 1970.

5. Woodson, R.O., Personal Communication. Honeywell Inc., Minneapolis, Minnesota, August 1972.

REFERENCES

1. Cohen, B.J., Henke, A.H., and Williams, L.G., A research program for investigating human performance with the helmet-mounted sight and display (HMS/D) system. Honeywell Inc., Minneapolis, Minnesota. Systems and Research Division document Z9500-3011, July 1972.

2. Hughes, R.J., Henke, A.H., and Schultz, R.L., Helmet-mounted sight/display applications. Volume IV: Baseline HMS/D system. Air Force Technical Report AFFDL-TR-69-118, Vol. IV, December 1969.

3. Jacobs, R.S., Triggs, T.J., and Aldrich, J.W., Helmet-mounted display/sight system study. Air Force Flight Dynamics Laboratory, Wright-Patterson Air Force Base, Ohio. Technical Report AFFDL-TR-70-83, Vol. 1, March 1971.

4. Williams, L.G., Fairchild, D.D., Graf, C.P., Jola, J.F., and Trumm, G.A., Visual search effectiveness for night vision devices. Contract No. DAAK02-67-C-0472, Army Night Vision Laboratory. Fort Belvoir, Virginia. May 1970.

5. Woodson, R.O., Personal Communication. Honeywell Inc., Minneapolis, Minnesota, August 1972.

APPENDIX A
INSTRUCTION TO SUBJECTS

INSTRUCTIONS TO SUBJECTS IN THE DETECTION GROUP

In this study we want to evaluate your ability to perform two tasks while wearing this helmet (show HMS/D).

Here are three groups of three lights. Going from left to right, they are 1-2-3 of group one, 1-2-3 of group two, and 1-2-3 of group three. On the console in front of you are three 3-position rotary switches corresponding to each group. One light from each group will illuminate. Your task will be to rotate the switches so that they point to the number of the illuminated light. As soon as you have done this, push the two large black buttons simultaneously. (Demonstrate) If you are correct, the lights will go off and three others will come on. This counter will keep track of the number of times you have correctly identified the three lights. At the end of the experiment you will be given a cash reward of 5 cents for each set which you have correctly identified, so it is to your advantage to work rapidly but accurately. At random intervals (without warning) three of these numbered hanging signs will illuminate. Your other task will be to determine which three are on and to quickly press the appropriate red button. These lights are on for one second and you have only an additional few seconds to respond. For each one that you miss or if you take longer than 5 seconds to respond, you will be penalized 50 cents, so you must work quickly and accurately. You may freely move your head to scan the lights. The sum of these three counters tells you how many you have missed.

1. Match the rotary switches to the light groups in front of you. If you get all three correct, you get 5 cents.

2. Identify the three numbered signs above you when they light. Errors or a response time greater than five seconds will cost you 50 cents.

3. Speed and accuracy are very important for both tasks -- it is possible to make $10 or more.

4. If you need to take a break, tell me.

5. Any questions?

6. Good luck.

INSTRUCTIONS TO SUBJECTS IN THE RECOGNITION GROUP

The instructions to subjects in the recognition group were identical to those given to the detection group, except for the following substitution, "this green light will appear" for "without warning."

Table B1. Target Presentation Scenario

Trial	Block I Lights			II			III			IV			V			VI		
1	1	3	6	3	15	5	6	1	3	10	5	11	5	10	1	3	1	4
2	5	[illegible]	2	8	7	1	2	16	5	1	7	13	8	14	3	16	10	9
3	7	9	5	15	13	9	9	2	15	16	12	9	13	11	7	7	12	1
4	9	1	15	11	5	2	1	7	9	4	3	14	2	16	5	10	11	16
5	11	10	3	1	12	8	14	9	8	15	4	7	10	4	8	15	3	6
6	2	11	4	6	8	3	10	3	16	8	1	16	6	7	10	5	8	14
7	14	5	10	9	4	13	15	5	10	3	8	6	11	12	6	12	7	11
8	6	15	9	5	11	7	4	14	13	14	2	15	3	13	9	13	9	2
9	15	8	11	7	3	10	16	6	11	7	9	3	7	2	16	1	4	13
10	3	6	1	2	9	11	11	12	6	12	14	5	16	15	13	14	6	12
11	13	4	14	16	1	6	8	4	14	9	11	4	4	5	11	2	5	10
12	16	2	7	13	10	12	7	13	2	2	13	10	9	6	15	9	2	7
13	8	13	12	4	16	14	12	11	1	6	16	2	14	3	2	11	14	8
14	12	16	13	14	2	15	5	10	4	11	6	12	12	8	14	6	16	15
15	10	14	8	10	6	15	13	15	12	13	10	8	15	1	12	8	13	5
16	4	12	16	13	14	4	3	8	7	5	15	1	1	9	4	4	15	3

Table C1. Number Correct Responses

Recognition

Subject	Visor A*	B	C	D	E	F
1	13	15	15	16	15	15
2	16	16	16	16	16	16
3	16	16	14	11	14	16
4	15	14	15	14	15	16
5	16	16	15	16	15	16
6	5	6	8	13	12	9
ΣX	81	82	83	86	87	88
$\bar{X}$	13.50	13.66	13.83	14.33	14.50	14.66

Detection

Subject	Visor A*	B	C	D	E	F
7	15	16	14	16	15	16
8	15	15	15	16	14	15
9	15	16	15	15	15	16
10	16	16	16	16	15	16
11	15	16	15	15	13	15
12	13	11	15	16	14	14
ΣX	89	90	90	94	86	92
$\bar{X}$	14.83	15.00	15.00	15.66	14.33	15.33

*Control Visor

Table C2. Mean Response Time (Seconds)

Recognition

Subject	Visor A*	Visor B	Visor C	Visor D	Visor E	Visor F
1	2.6	3.1	2.9	2.9	2.9	2.9
2	2.4	2.4	2.5	2.5	2.2	2.4
3	2.9	2.9	3.2	3.2	3.1	2.8
4	3.2	3.2	3.0	3.3	3.3	3.1
5	2.8	3.0	2.7	2.9	3.0	2.7
6	3.8	3.8	3.8	3.5	3.6	3.6
Σ	17.7	18.4	18.1	18.3	18.1	17.5
X̄	3.0	3.1	3.0	3.0	3.0	2.9

Detection

Subject	Visor A*	Visor B	Visor C	Visor D	Visor E	Visor F
7	2.8	2.5	2.8	2.7	2.8	2.7
8	2.5	2.9	2.9	2.8	2.9	2.6
9	2.8	2.9	3.1	2.9	2.8	2.8
10	2.5	2.7	2.6	2.6	2.8	2.6
11	3.2	2.6	2.9	2.9	3.0	3.1
12	3.2	3.2	2.9	2.9	3.0	3.1
Σ	17.0	16.8	17.2	16.8	17.3	16.9
X̄	2.8	2.8	2.9	2.8	2.9	2.8

*Control Visor